Grille and Method and Apparatuses for Manufacturing It

Background of the Invention

1. Field of the Invention

The present invention relates to curved tubular bars and methods and apparatuses for manufacturing them. More particularly, the invention relates to stainless steel curved tubular bars having thin sidewalls, and to methods and apparatuses for manufacturing them and assembling them into a grille, for example a radiator grille for a motor vehicle.

2. Description of Related Art

Bars, including tubular bars, have many applications in manufacturing, including use as parts in motor vehicles. When thoughtfully designed, bars that are tubular, instead of solid, can strike a useful balance between robustness on the one hand and amount of material, as measured in weight and cost, on the other hand.

Radiator grilles are an illustrative application for such bars, and provide interesting examples of past attempts to strike this balance in the bars that function as grille slats. In this application, the bars need to be robust but also light and inexpensive. Additionally, current market tastes dictate that each slat should be an elongated prism, deeper than it is thick; all surfaces of the prism should be coated black except for the front surface, which should be polished metal. The slats need not be linear, and in fact it is generally desirable that some portions follow a gentle curve along the horizontal plane.

Achieving the desired configuration poses certain technical challenges. First, the slat material should be robust and should hold a good polish, but it should also be light and easy to bend through the desired curves. Second, the slat should

require a minimum number of manufacturing and assembly steps to keep production costs down.

One popular slat is formed as a simple aluminum extrusion that has all surfaces painted black, except for the front surface, which is polished. Observations of the slat in use indicate that the polished front surface does not stand up well to age or use; it nicks, oxidizes and discolors.

An improved slat is also formed as an aluminum extrusion that is painted black; however this slat also includes a polished stainless steel strip that is affixed to the front surface of the extrusion. In some cases, the strip is affixed to the extrusion with only adhesive; in other cases, a key and channel coupling supplements the adhesive. Observations of this slat in use indicate that the polished stainless steel strip holds its appearance better than the polished aluminum; however, the joint between the strip and the extrusion seems to be a likely point of failure. Another disadvantage is that the slat requires two parts to be manufactured and then assembled, increasing production costs accordingly.

In considering the slats described above, it can be seen that stainless steel is a desirably robust material to use. Unfortunately, stainless steel is more difficult to bend through curves than aluminum and is too heavy and expensive to use in solid bars. When a stainless steel tubular bar is bent, there is a tendency for its sidewalls to buckle either inward or outward, weakening the bar and ruining its appearance. For this reason, stainless steel slats currently available in the marketplace tend to be formed as small-diameter cylindrical tubes that better resist such bending-induced buckling than do prismical tubes with their sharp edges. However, it seems that the marketplace has rejected these cylindrical slats because they don't produce the desired appearance; their whole circumference is uniformly polished, no part is coated black, and they are not deeper than they are thick.

Accordingly, there is a need for a way to manufacture a stainless steel prismical tube that can be bent through curves along its longitudinal axis to form the desired slat, but without buckling the sidewalls. Although it can be difficult to bend an expensive and heavy solid stainless steel prism, a tubular stainless steel prism has the same outward appearance and enjoys similar robustness and polish with less weight and less material cost, and without recourse to complicated manufacturing or assembly steps needed for hybrid solutions as described above.

Summary of the Invention

The present invention is directed to a way to bend a tube without buckling the tube walls.

According to one aspect of the invention, there is provided a method of bending a tube through a desired curvature along its longitudinal axis. The method includes reinforcing a portion the tube with a core that allows the portion to bend but that resists buckling of the tube walls and then bending the reinforced portion of the tube. Reinforcing a portion of the tube includes inserting into the tube a longitudinally bendable core that resists transverse compression, whereby the core redistributes transverse forces applied to the portion. The core may be removed after bending the reinforced portion of the tube.

The core may be formed from granules, liquid, or a spring mechanism. The ends of the tube, or even just the portion, can be sealed to discourage the core from coming out.

The method is well suited for use on tubes having a polygonal cross-section, including a quadrilateral, parallelogrammic or rectangular cross-section. The tube may be formed from metal, including stainless steel, and may have sidewalls with a range of thicknesses, including the range between one tenth of one millimeter and one millimeter. In particular, a sidewall thickness of one tenth of one millimeter

provides a good balance between robustness and the amount of steel used, as measured in weight and cost of material.

Bending the reinforced portion of the tube may be performed by rolling the portion between rollers that define between them a path having the desired curvature, including feeding the portion through a channel defined between the rollers that is substantially congruent with the outside perimeter of the portion.

This method of manufacture might also include squaring the tube, by which is meant at least one of squaring the cross-section of the portion and longitudinally untwisting the portion. Such squaring may be performed by rolling the tube between rollers that define between them a substantially straight path, including feeding the portion through a channel defined between the rollers that is substantially congruent with the outside perimeter of the tube.

According to another aspect of the invention, there is provided a tube having a desired curvature along its longitudinal axis, made in accordance with the method just described above.

According to another aspect of the invention, there is provided an apparatus for bending an elongated body having a predetermined cross-section through a desired curvature along its longitudinal axis. The apparatus includes: a housing; and first, second, and third rollers, each roller respectively having an axis of rotation and a rolling surface, the rollers being rotatably mounted on the housing such that their respective axes of rotation are substantially parallel and their respective rolling surfaces define between them a channel having the desired curvature and a cross-section substantially congruent with the cross-section of the body.

According to another aspect of the invention, there is provided an apparatus for squaring an elongated body having a predetermined cross-section. The apparatus includes: a housing; and first and second rollers, each roller respectively

having an axis of rotation and a rolling surface, the rollers being rotatably mounted on the housing such that their respective axes of rotation are substantially parallel and their respective rolling surfaces define between them a channel having a cross-section substantially congruent with the cross-section of the body.

According to yet another aspect of the invention, there is provided an apparatus for reinforcing a portion of a tube during manufacturing. This apparatus includes a core having an outer diameter substantially equal to the inner diameter of the tube that allows the portion to bend along its longitudinal axis but that resists buckling of the sidewalls of the portion. The core itself may be bendable along its longitudinal axis and may resists transverse compression, such that it is operable to redistribute transverse forces applied to the portion.

This core may be formed from a plurality of granules such as sand, a volume of liquid such as water or hydraulic oil, or a spring mechanism such as a coil spring that has an outside perimeter substantially congruent with the inside perimeter of the portion.

According to still another aspect of the invention, there is provided a stainless steel tube having a desired curvature along its longitudinal axis, a substantially polygonal cross-section, and a sidewall thickness in a range between one tenth of one millimeter and one millimeter or even the range between one tenth of one millimeter and five tenths of one millimeter. A sidewall thickness of one tenth of one millimeter a good balance between robustness and the amount of steel used, as measured in weight and cost of material. The tube may be made of various stainless steel alloys, including iron-chromium-nickel alloy 304.

According to another aspect of the invention, there is provided a grille having a plurality of stainless steel tubes as described in the paragraph immediately above, in spaced-apart disposition and means for connecting adjacent tubes,

including crosspieces connected to the tubes by conventional means, including welds, spot-welds, adhesive, or fasteners.

Further aspects and advantages of the present invention will become apparent upon considering the following drawings, description, and claims.

Description of the Invention

The invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawing figures, in which like reference numerals designate like parts throughout the various figures.

1. Brief Description of the Drawings

Figure 1: is a front isometric view a grille assembled from a plurality tubular bars, in accordance with one aspect of the present invention;

Figure 2: is a back isometric view of the grille of Figure 1;

Figure 3: is a back isometric view of the grille of Figure 1, detailing an end portion of the tubular bars;

Figure 4: is a plan view of the grille of Figure 1;

Figure 5: is a front elevational view of the grille of Figure 1;

Figure 6: is a back elevational view of the grille of Figure 1;

Figure 7: is a right elevational view of the grille of Figure 1;

Figure 8: is a front isometric view of one tubular bar of the grille of Figure 1, in accordance with another aspect of the present invention;

Figure 9: is a back isometric view of the tubular bar of Figure 8;

Figure 10: is a back isometric view of the tubular bar of Figure 8, detailing an end portion of the tubular bar;

Figure 11: is a plan view of the tubular bar of Figure 8;

Figure 12: is a front elevational view of the tubular bar of Figure 8;

Figure 13: is a back elevational view of the tubular bar of Figure 8;

Figure 14: is a right elevational view of the tubular bar of Figure 8;

Figure 15: is a front elevational view of an apparatus for bending the end portion of the tubular bar of Figure 10, in accordance with another aspect of the present invention;

Figure 16: is a right elevational view of the bending apparatus of Figure 15;

Figure 17: is a plan view of the bending apparatus of Figure 15;

Figure 18: is a front isometric view of the bending apparatus of Figure 15;

Figure 19: is a front isometric view of the bending apparatus of Figure 15, sectioned along the line A-A to highlight a feed-path through the apparatus;

Figure 20: is a front isometric view of the bending apparatus of Figure 15 the end portion of the tubular bar of Figure 10 on the feed-path;

Figure 21: is a front isometric view of the bending apparatus of Figure 15 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line B-B to highlight a reinforcing-core within the end portion of the tubular bar;

Figure 22: is a front isometric view of the bending apparatus of Figure 15 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line B-B to highlight a granular reinforcing-core within the end portion of the tubular bar;

Figure 23: is a front isometric view of the bending apparatus of Figure 15 the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line B-B to highlight a liquid reinforcing-core within the end portion of the tubular bar;

Figure 24: is a front isometric view of the bending apparatus of Figure 15 the end portion of the tubular bar of Figure 10 the feed-path, sectioned along the line B-B to highlight a mechanically-sprung reinforcing-core within the end portion of the tubular bar;

Figure 25: is a front isometric view of the bending apparatus of Figure 15 the

end portion of the tubular bar of Figure 10 on the feed-path, the end portion of the tubular bar having both ends sealed to contain the reinforcing core;

Figure 26: is a front elevational view of an apparatus for squaring the tubular bar of Figure 8, in accordance with another aspect of the present invention;

Figure 27: is a right elevational view of the squaring apparatus of Figure 26;

Figure 28: is a plan view of the squaring apparatus of Figure 26;

Figure 29: is a front isometric view of the squaring apparatus of Figure 26;

Figure 30: is a front isometric view of the squaring apparatus of Figure 26, sectioned along the line C-C to highlight a feed-path through the apparatus;

Figure 31: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path;

Figure 32: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line D-D to highlight a reinforcing-core within the end portion of the tubular bar;

Figure 33: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line D-D to highlight a granular reinforcing-core within the end portion of the tubular bar;

Figure 34: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line D-D to highlight a liquid reinforcing-core within the end portion of the tubular bar;

Figure 35: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path, sectioned along the line D-D to highlight a mechanically-sprung

reinforcing-core within the end portion of the tubular bar; and

Figure 36: is a front isometric view of the squaring apparatus of Figure 26 with the end portion of the tubular bar of Figure 10 on the feed-path, the end portion of the tubular bar having both ends sealed to contain the reinforcing core.

2. Detailed Description of Specific Embodiments

(a) Structure

The invention will now be further illustrated by way of specific exemplary embodiments shown in the drawings and described in greater detail herein.

Figures 1 through 7 show a grille according to one aspect of the present invention, generally illustrated at 50. The grille 50 is an assembly of spaced-apart tubular bars 52 held together by crosspieces 54. A crosspiece 54 may engage a bar 52 by any conventional means, for example a weld, a spot-weld, an adhesive, or a fastener.

With reference now to Figures 7 - 14, a representative bar 52 according to one aspect of the invention will be described in further detail. The bar 52 may be formed from any suitably robust and ductile material, including metal, including stainless steel, including iron-chromium-nickel alloy 304. The bar 52 may have any cross-sectional perimeter, including a polygon, including a quadrilateral, including a trapezoid or a parallelogram, including a rectangle, including a square. To save weight and the cost of materials, the bar 52 is tubular, having sidewalls 56 with a thickness in the range of between 0.1 millimeter to 1 millimeter, although other ranges might be chosen to strike an appropriate balance of physical and economic characteristics desirable for a particular application. Better cost and weight savings can be achieved by specifying sidewalls 56 with a thickness in the range of between 0.1 millimeter to 0.5 millimeter. Even better savings can be achieved by specifying sidewalls 56 with a thickness of approximately 0.1 millimeter. The two

end portions 58 of the bar 52 may be left open for drainage or sealed for protection. Each of the exterior surfaces 60 of the bar 52 may be coated, for example painted, or polished. The bar 52 may be curved along its longitudinal axis; as illustrated it has been bent through a large radius of curvature RL proximate its middle portion 62 and a small radius of curvature RS proximate each of its two end portions 58.

With reference now to Figures 15 - 25, a method and apparatus for bending a portion of the bar 52 will be described in further detail. It should be understood that the portion may be the whole bar 52. The same description applies to an apparatus for bending the bar 52 through the large radius of curvature RL and the small radius of curvature RS, but for conciseness only the latter will be described. It should be recognized however that the two operations could be performed on two different bending apparatuses or that the two operations could be performed in succession on the same bending apparatus, with the bending apparatus being reconfigured between performance of the two operations.

With reference first to Figures 15 - 19, a bending apparatus according to one aspect of the invention is generally illustrated at 70. The bending apparatus 70 has a housing 72 on which are mounted three or more rollers 74 with substantially parallel axes of rotation. Between them, the three rollers 74 define a feed-path 76 through a desired radius of curvature, in this case the small radius of curvature RS. The rollers 74 may define grooves 78 for improved material handling and adjacent grooves 78 may in turn define between them a channel 80 having a cross-section substantially congruent with the cross-sectional perimeter of the bar 52. This channel 80 acts to reinforce the bar 52 from the outside, to help prevent the cross-section of the bar 52 from skewing and prevent the sidewalls 56 from buckling during the bending operation.

With reference now to Figure 20, an end portion 58 of the bar 52 can be seen positioned for bending within the bending apparatus 70.

With reference now to Figures 21 - 25, the inclusion of a reinforcing-core 82 inside the bar 52 will now be described. Figures 21 - 24 show a reinforcing-core 82 inserted within the end portion 58 of the bar 52. The reinforcing-core 82, which is bendable along its longitudinal axis but otherwise substantially incompressible, permits the bending apparatus 70 to bend the end portion 58 of the bar 52 through the desired small radius of curvature RS, but helps to prevent the cross-section of the bar 52 from skewing and the sidewalls 56 from buckling during the bending operation by opposing, redirecting and distributing the transverse forces applied by the rollers 74.

As shown respectively in Figures 22, 23, and 24, the reinforcing-core 82 may for example be formed as: a packed mechanical mixture of granules 84 such as sand, a volume of liquid 86 such as water or hydraulic oil, or a spring mechanism 88 such as a coil spring.

For the reinforcing-core 82 to work well, it should be located at least within that portion 58 of the bar 52 that is being bent; if it were to slide within the bar 52 away from that portion 58, it might not provide as good reinforcement. There are a number of ways to prevent such sliding. One way is to completely fill the bar 52 with the reinforcing-core 82 so that the reinforcing-core 82 cannot slide within bar 52. This solution can be augmented by sealing the ends of the bar 52 so that the reinforcing-core 82 cannot slide out. Another way is to fill just that portion 58 of the bar 52 being bent with the reinforcing-core 82 and to seal just that portion 58. Either way, the whole bar 52 or just the portion 58 being bent can be sealed in any well know way, for example by inserting a plug 90 or injecting a temporary adhesive or sealing compound that can resist forces applied by the reinforcing-core 82 but that can be easily removed after manufacturing has been completed.

With reference now to Figures 26 - 36, a method and apparatus for squaring the bar 52 will be described in further detail. In essence, the prior manufacturing

operations, including the bending operation, might have introduced in places along the bar 52 a small twist along its longitudinal axis and/or a small skew of its cross-sectional perimeter, which results could benefit from mitigation.

With reference first to Figures 26 - 30, a squaring apparatus according to one aspect of the invention is generally illustrated at 92. The squaring apparatus 92 has a housing 94 on which are mounted two rollers 96 with substantially parallel axes of rotation. Between them, the two rollers 96 define a substantially linear feed-path 98. The rollers 96 may define grooves 100 for improved material handling and adjacent grooves 100 may in turn define between them a channel 102 having a cross-section substantially congruent with the cross-sectional perimeter of the bar 52. In operation, this channel 102 acts as a die to squeeze the bar 52 back into a square and untwisted disposition.

With reference now to Figure 31, an end portion 58 of the bar 52 can be seen positioned for squaring within the squaring apparatus 92.

With reference now to Figures 32 - 36, the inclusion of a reinforcing-core 82 is shown. The reinforcing-core 82 may be the same one as used during the bending operation, or else it may be a different one that has been optimized for the physical forces and desired results of the squaring operation.

(b) Operation

With reference to the drawings, the operation of these specific embodiments of the invention will now be described in greater detail.

The manufacturer fabricates or acquires a conventional and substantially straight piece of tube-stock having the desired cross-sectional shape, which in the case of this specific example is a tubular bar 52 having a rectangular cross-section and sidewalls 56 having a thickness in the range of 0.1mm to 1mm.

The manufacturer then inserts into the bar 52 a reinforcing-core 82, for example a packed mechanical mixture of granules 84, a volume of liquid 86, or a spring mechanism 88. The reinforcing-core 82 is placed either to extend along the whole length of the bar 52 or else at least proximate to the portion 58 of the bar 52 being worked on. Once placed, the reinforcing-core 82 is sealed in place with a plug 90 for at least the duration of the work.

The manufacturer then configures the bending apparatus 70 to bend a portion of the bar 52 through a desired radius of curvature along its longitudinal axes, which in the present example is bending the end portion 58 of the bar 52 through the small radius of curvature RS. To configure the bending apparatus 70, one adjusts the size and relative position in the plane of the rollers 74 to achieve the desired feed-path 76 and channel 80. One might select rollers 74 with grooves 78 that between them define a channel 80 that has a cross-section that is substantially congruent with the cross-sectional perimeter of that portion 58 of the bar 52 being bent.

Once the bending apparatus 70 has been configured, the manufacturer draws the portion 58 to be bent through the channel 80 along the feed-path 76, allowing the rollers 74 to apply transverse forces to that portion 58 to urge it to bend through the small radius of curvature RS.

A similar process would be followed to bend the middle portion 62 of the bar 52 through the large radius of curvature RL, and in fact for ease of manufacturing that bending operation would likely be performed before the operation of tightly bending the end portion 58 of the bar 52 through the small radius of curvature RS.

It is possible that during prior manufacturing steps, including bending operations, a small cross-sectional skew or longitudinal twist could be introduced into the bar 52. If so, this result can be mitigated by using the squaring apparatus 92.

In preparation for the squaring operation, the manufacturer might either leave the reinforcing-core 82 in place within the bar 52 or else might remove the reinforcing core altogether or else replace it with one having different bending and compression characteristics more suitable for the squaring operation.

The manufacturer then configures the squaring apparatus 92 to square the bar 52 and specifically the portion 58 of the bar 52 that has been bent. To configure the squaring apparatus 92, one adjusts the size and relative position in the plane of the rollers 96 to achieve the desired feed-path 98 and channel 102. One might select rollers 96 with grooves 100 that between them define a channel 102 that has a cross-section that is substantially congruent with the cross-sectional perimeter of the portion 58 of the bar 52 being squared.

Once the squaring apparatus 92 has been configured, the manufacturer draws the bar 52, and in particular that portion 58 of the bar 52 that has been bent, through the channel 102 along the feed-path 98, allowing the rollers 96 to urge against the bar 52 to counteract any longitudinal twist or cross-sectional skew.

Once the bar 52 has been bent and squared as needed, the manufacturer may remove the plugs 90 and the reinforcing-core 82 for reuse or disposal, thereby reducing the weight of the bar 52. Alternatively, the manufacturer might chose to keep the reinforcing-core 82 within the bar 52, particularly where the reinforcing-core is cheaper and lighter than a solid bar 52 would have been.

The external surfaces 60 of the bar 52 can then be painted or polished as desired, and the end portions 58 can be sealed for protection or left open for drainage, also as desired.

The manufacturer can thus make a set of such bars 52, the bars being either identical or varying in shape and size as needed to produce in aggregate a desired shape of grille 50. To assemble the bars 52 into the grille 50, the manufacturer

places the bars 52 in the desired space-apart disposition and secures them in their relative position with crosspieces 54 attached in a conventional manner, for example with a weld, a spot-weld, some adhesive, or a fastener.

Thus, it will be seen from the foregoing examples that there has been described: a method of bending a tube through a desired curvature along its longitudinal axis; a tube having a desired curvature along its longitudinal axis made in accordance with this method; an apparatus for bending a tube having a predetermined cross-section through a desired curvature along its longitudinal axis; an apparatus for squaring a tube having a predetermined cross-section; an apparatus for reinforcing a portion of a tube during manufacturing; a stainless steel tube having a desired curvature along its longitudinal axis, a substantially polygonal cross-section, and a sidewall thickness in a range between one tenth of one millimeter and one millimeter; and finally a grille assembled from a plurality of such stainless steel tubes in spaced-apart disposition and means for connecting adjacent tubes together, including crosspieces connected to the tubes by conventional means, including welds, spot-welds, adhesive, or fasteners.

While specific embodiments of the invention have been described and illustrated, such embodiments should be considered as only examples of the invention and not as limiting the invention itself, which is to be construed in accordance with the accompanying claims.

While the invention has been described as having particular application for grilles, those skilled in the art will recognize it has wider application both in the automotive sector and beyond.